**Leveraging Global Communications Capabilities in the 618 AOC**

GRADUATE RESEARCH PAPER

June 2015

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# LEVERAGING GLOBAL COMMUNICATIONS CAPABILITIES IN THE 618 AOC

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## Abstract

As the execution arm of Air Mobility Command's global mission, the 618 Air Operations Center (618 AOC) requires a secure global communication capability that it currently lacks. It also requires the ability to use tactical datalinks and manage a common operational picture in support of global command and control. This paper discusses ten current or emerging systems that will provide these capabilities as well as the equipment, software, and personnel that the 618 AOC needs in order to access those systems. Using a cost-benefit analysis, this paper provides recommendations on the equipment and software that 618 AOC should purchase or develop. The paper also suggests the creation of a joint interface control cell (JICC) within 618 AOC to handle tactical datalinks and manage the common operational picture. The main purpose of this paper is to provide 618 AOC with the proper systems and personnel to excel in Networking, Predictive Battlespace Awareness, Dynamic Battlespace Management, and Integrated and Responsive Air Mobility Operations.

*To my wife, my girls, and my boy.*
*Thank you for your patience and support.*

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Kevin L. Parsons

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# I. Introduction

## General Issue

As the execution arm of Air Mobility Command (AMC), the 618th Air Operations Center (618 AOC), more commonly referred to as the Tanker and Airlift Control Center (TACC), is the epicenter of mobility air force (MAF) operations. TACC "plans, schedules and directs a fleet of nearly 1,100 mobility aircraft in support of combat delivery and strategic airlift, air refueling and aeromedical evacuation operations around the world" (618 AOC PA, 2015, p. 1). Thanks to emerging communication technology, the potential exists for TACC to realize unprecedented access to global C2 of its assets. This access will come at a price and will require additional manpower within TACC. However, the end result will bring benefits that are well worth the costs.

## Problem Statement

TACC currently lacks the equipment and manpower necessary to take full advantage of the advanced communication equipment aboard many of its mobility assets. The addition of global communications capabilities in TACC will significantly enhance its global command and control of mobility platforms.

## Research Objectives/Questions/Hypotheses

The hypothesis of this research project is that TACC stands to gain considerable C2 advantages through an investment in advanced communication equipment and the personnel necessary to support and operate that equipment. To determine whether or not TACC will see an adequate return on such an investment, this research project seeks to answer the following questions:

1. What current and emerging communications equipment can TACC use to communicate with aircraft?
2. What equipment and personnel are required to access this technology? Is a joint interface control cell (JICC) required?
3. What are the costs of equipment, personnel, and operations?
4. What benefits will TACC gain from use of this technology?
5. What are the benefits of creating a JICC?
6. How do the costs compare to the benefits of implementation of this technology?

**Research Focus**

The focus of this research centers on potential gains in C2 capability within TACC based on the addition of communication equipment and the necessary supporting personnel. More specifically, the research looks into current and emerging communication capabilities aboard AMC aircraft to which TACC does not currently have access. Armed with this knowledge, the research then turns to cost and manpower. The critical question to answer is whether or not the benefits of adding the necessary personnel and equipment will be worth the cost.

## Methodology

A cost-benefit analysis is provided to support the conclusions presented in this paper. The goal of a cost-benefit analysis is to justify a set of recommendations by finding an optimal balance between capabilities and affordability (US DoD, 2011). The costs presented in this study are the rough order of measure (ROM) purchase and operational expenses of the ground-based equipment that TACC will need in order to capitalize on current and emerging communication systems. The benefits are the extent to which each communication system provides TACC with certain desired effects. Costs are directly quantitative (U.S. dollars). Benefits, however, are converted from qualitative (effectiveness of a communication system) to quantitative (a score based on the extent to which the communication system contributes to a desired effect).To accomplish this conversion, metrics are assigned to each desired effect, then each communication system receives a score based on the extent to which the system satisfies each of the metrics. The expertise of several subject matter experts (SMEs) is used to validate this qualitative-quantitative conversion.

## Assumptions/Limitations

The most significant limitation of this study lies in the challenge of assigning appropriate costs to each of the systems listed. Costs vary with time, and individuals involved in past purchases change positions, making them difficult to locate. Costs also vary based on capability. A single system or software can often be tailored to the needs of the customer, which results in tailored pricing as well. For these reasons, ROM costs are presented in this paper. While these costs may not precisely indicate the true purchase and operations and maintenance (O&M) costs, they provide sufficient information to allow cost comparison and cost-benefit analysis. It is also important to note that the costs presented in this paper are not tied to a specific vendor or level of system capability. Costs must be evaluated on a case-by-case basis when considering a purchase.

A key assumption of this paper is that TACC will continue to maintain the systems it currently has and will continue to develop systems that it was developing at the time this paper was written. This assumption is critical because TACC is already familiar with the costs associated with these systems. Thus cost information for these systems is not included in the analysis below.

**Implications**

Full capitalization of current and emerging communication systems will require significant investment on the part of AMC. It will require purchases in excess of $4,000,000 in equipment and software, more than $250,000 annually in O&M expenses, and the creation of as many as 19 positions within TACC. The extent to which AMC is willing to accept these costs will determine the amount of enhanced global C2 within TACC.

Beyond the scope of this research project, but still an important implication, is the requirement to develop various forms of guidance and documentation related to new equipment and positions. Concepts of employment and operations must be developed. Memoranda of understanding and agreement between various theaters may be required. A process management plan should be put in place. Each of these requirements needs additional analysis that this paper does not provide.

A final implication is that which follows the addition of any form of technology. TACC and the missions it executes will have new sources of vulnerability. Be it in the form of cyber vulnerability over the non-secure internet protocol router (NIPR) and secure internet protocol router (SIPR) lines, or communication vulnerability via secured satellite communications (SATCOM), TACC must ensure processes are in place to monitor its systems and protect against collection and attack. To this end, a separate risk analysis should be completed.

# II. Literature Review

## Chapter Overview

This chapter presents the relevant research associated with the recommendations expressed in this paper.

## TACC C2 Deficiencies and Desired Effects

Capabilities Based Planning Deficiencies, Round 4 (AMC, 2014) is a report listing several deficiencies within the MAF as well as potential solutions to those deficiencies. Each of the problems the report presents can be tied to one primary cause: a lack of global, real-time communication between MAF aircraft and C2. This problem is manifested in multiple ways. For instance, a lack of secure connectivity prevents MAF aircrew from exchanging secure information globally with C2 nodes. Inadequate means for data exchange limits MAF aircrews' "ability to view, manage, and/or report operational and tactical C2 information" (AMC, 2014, p. 212). The key point is that the lack of communication between MAF C2 and aircraft leads to suboptimal operations and increased operational costs and risks.

The Mobility Air Forces Global Secure Command and Control Airborne and Ground Communications Operating Concept (MAF GSC2AGC OC) "defines the desired end state of global, secure communications for command and control of airborne and ground mobility air forces." (AMC/A3C, 2014, p. 1). The "end state" presented in the MAF GSC2AGC OC will eliminate the communication problems listed in the Capabilities Based Planning Deficiencies document by ensuring MAF aircraft and C2 agencies have global access to protected communications connectivity and aircrew decision support applications.

The MAF GSC2AGC OC is this paper's main source of information on desired TACC capabilities because it develops an infrastructure that meets the desired capabilities documented in a myriad of reports and documents, to include:

- Capstone Concept for Joint Operations
- Net-Centric Environment Joint Functional Concept
- Command and Control Functional Concept
- Focused Logistics Joint Functional Concept
- Global Mobility (GM) Concept of Operations (CONOPS)
- Space and Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance CONOPS
- MAF Airborne Networking Enabling Concept
- Integrated Flight Management (IFM) Concept
- MAF C2 Framework Capability Development Document (CDD)
- Advanced Situational Awareness and Countermeasures (ASACM) CDD
- To-Be MAF Airborne Communications Architecture

In developing the infrastructure that meets its desired end state, the MAF GSC2AGC OC describes nine desired effects. The four effects that receive the greatest benefit from the various systems listed in this paper are presented in Table 1. These desired effects are used in this paper to demonstrate how a specific communication system will benefit TACC.

**Table 1. MAF GSC2AGC OC Desired Effects**

| Desired Effect | Description |
|---|---|
| Networking | Provide MAF assets global access to information enhancing C2 and decision making. Allow rapid reporting of critical information to C2 channels. |
| Predictive Battlespace Awareness (PBA) | Understanding of battlespace conditions and changes that permits commanders and staffs to shape the battlespace, exploit emerging opportunities, and influence adversary behavior. |
| Dynamic Battlespace Management (DBM) | Capability to dynamically and proactively command and control assets during ongoing operations. Shortens the effects chain, improving mission effectiveness and warfighter support. |
| Integrated and Responsive Air Mobility Operations | Ability of TACC and theater AOCs to plan and execute missions across geographic and organizational boundaries. Seamless integration of Mobility and Combat Air Forces. |

**AMC Asset Capabilities**

As previously indicated, many MAF aircraft are equipped with a wide range of communication systems. There are also a few systems that TACC is pursuing that are not aircraft specific. The MAF GSC2AGC Roadmap (AMC, 2014) – a follow on to the operational concept of the same name – provides a comprehensive list of communication systems that are equipped or available for MAF aircraft and TACC. Pertinent systems, associated aircraft, and brief descriptions of system capabilities are presented Table 2. Some of the more complicated terminology and systems are explained here to assist the reader in understanding the capabilities that these systems provide.

Six of the systems listed below make use of tactical datalink (TDL). These systems are DRC, RTIC, ROBE, CTII, and UDOP (see Table 2 for full names and descriptions). Tactical datalink is simply means of sharing information over an electronic network (AFTTP 3-3.KC-135, 2013). The information that is shared comes primarily from aircraft sensory information (e.g. the radar of an F-22) and avionics (e.g. altitude, geographic location). Some TDLs also allow voice and text communications. Information

**Table 2. AMC Communication Capabilities – Current and Emerging**

| System | Aircraft | Capability |
|---|---|---|
| Real-Time Information in the Cockpit (RTIC) | C-17A<br>C-130J<br>C-130H*<br>KC-135R | Allows transmission/reception of TDL both LOS and BLOS using JREAP-A through a UHF SATCOM radio (BLOS) (AMC, 2011). |
| Dynamic Retasking Capability (DRC) | C-17A<br>C-130J | Roll-on system. Allows transmission/reception of TDL both LOS and BLOS using JREAP-A through a UHF SATCOM radio. (AFTTP 3-3.C-130J, 2014). |
| Link 16 | C-130J<br>KC-46 | A network allowing all participating aircraft to transmit sensory and avionics information and receive all information from the network providing an integrated common tactical picture (AFTTP 3-3.KC-135, 2013). Typically LOS. Transmitted BLOS using JREAP-A in the aircraft listed (Murra C. L., 2014), (AMC, 2014). |
| Tanker Airborne Long-Range Chat (TALC) | KC-135R<br>KC-10A | Iridium-based carry-on system providing secure C2 data exchange via Internet Relay Chat (AMC, 2014). Allows chat communication with aircraft over secure internet protocol (SIPR) computers. |
| Roll-On Beyond Line-Of-Sight Enhancement (ROBE) Spiral 3 | KC-135R<br>KC-46 | Provides LOS and BLOS relay/forwarding of TDL using JREAP-A through a UHF SATCOM radio. Acts as a gateway between TDLs – translates one TDL to another (Bridge, 2015). |
| Internet Protocol Beyond Line-of-Sight (SIPR/NIPR BLOS) | KC-46 | In-flight BLOS access to non-secure internet protocol (NIPR) and SIPR computer networks. Includes all functionalities of a typical SIPR or NIPR work station, such as e-mail with attachments, text chat, and web browsing (Murra C. L., 2014). |
| Combat Track II (CTII) | C-17A<br>C-130H/J<br>KC-135R<br>KC-10, C-5 | Provides encrypted BLOS communication over a UHF SATCOM radio, allowing text chat messaging, file transfer, and ITV of CTII users (AFTTP 3-3.C-17, 2014). |
| WAVE Radio Over Internet Protocol (WAVE) | | Enables TACC SIPR or NIPR workstations remote to access LOS radios, thereby allowing direct voice communication with aircraft globally. |
| Mobile User Objective System (MUOS) | C-17A<br>C-130H/J<br>KC-135R<br>C-5 | Provides cell phone-like data/voice service based on 3G cellular technology. Allows radio-to-radio and radio-to-network data and voice communication (Werner, 2014). |
| User-Defined Operational Picture (UDOP) | | Provides internet-based (NIPR/SIPR) fusion of more than 3000 data sources (e.g. TDL, Intel, Weather) allowing global SA and dynamic C2 of MAF forces (AMC/A3, 2015). |

over datalink is aggregated and displayed for the user in a graphical user interface that is commonly referred to as a common tactical picture (CTP) or common operational picture (COP). "A CTP is an integral part of daily operations for CCMDs [Combatant Commands], components, and DoD support agencies" (CJCS, 2014). It enhances C2 and aircrew situational awareness (SA) and decision making by providing real-time battlefield information such as the location of friendly and enemy forces. CTPs also allow alternate forms of communication between aircraft and C2.

Link 16 is the primary TDL used by the USAF. As shown in the table above, it is being integrated into the C-130J and will also be used on the KC-46. DRC, RTIC, and ROBE communicate with multiple TDLs, including Link 16. The line-of-sight (LOS) communication typical of Link 16 is extended beyond-line-of-sight (BLOS) by each of these systems using Joint Range Extension Application Protocol Alpha (JREAP-A). JREAP-A is simply a standardized form of communication that can be transmitted and received with an ultra-high frequency (UHF) satellite communication (SATCOM) radio. It must be noted, however, that JREAP-A's BLOS communication is not inherently global. Communications cannot extend beyond the satellite footprint in which the system is operating. For instance, a C-17 in Afghanistan can communicate with CENTAF's 609th AOC because they share the same satellite footprint. It cannot, however, communicate directly with TACC using JREAP-A because the C-17 and TACC are not within the same satellite footprint. For a C-17 over Afghanistan to communicate with TACC, it would have to send data to the 609th AOC using JREAP-A, then the message would have to be converted to JREAP-C, an internet protocol version of the same data, and sent to TACC over the internet.

While each of the systems listed so far is designed for use with Link 16, CTII is a TDL in and of itself. CTII lacks a lot of the capability of other TDLs. For instance, it does not integrate sensory information. It does, however, provide TACC a depiction of the geographic location of all aircraft with an operable CTII system. This makes it useful for in-transit visibility (ITV) - the ability to track a mission in real-time. It also provides classified chat and file transfer capabilities that give TACC alternatives to traditional forms of communication. As opposed to the Link 16 systems listed above, TACC already has the ability to communicate with CTII systems. Unfortunately, CTII is a roll-on system of which AMC has a very short supply.

Of each of the TDL systems, UDOP holds what is arguably the greatest potential. UDOP is capable of pulling information from TDLs that are available over NIPR and SIPR channels. It can also pull from various intelligence and weather sources. Overall, UDOP is capable of aggregating information from over 3000 data sources into a single, user-defined common operational picture. UDOP's greatest limitation is that it cannot communicate with any MAF aircraft at this time. A system called Airborne Web Services (AWS) is required for surface-to-air communication via UDOP. Since this paper focuses on modifications within TACC, discussion of AWS is not presented.

The remaining systems in Table 2 are easier to understand. The KC-46's BLOS NIPR and SIPR simply give KC-46 aircrew the ability to access NIPR and SIPR networks from the aircraft. TALC allows secure text chat between TACC and the aircraft. WAVE gives TACC the ability to use its computers to access radios all around the world in order to communicate with aircraft. Finally, MUOS allows TACC to communicate globally with aircraft by either voice or data.

## TACC Equipment and Software Requirements

Table 3 pairs airborne systems with the requisite ground-based equipment and software. In some instances, the requirement indicated is not the only option available. The process of deciding which type of equipment to list in this table is described in Chapter III, Methodology. Required equipment was determined through discussion with several subject matter experts. Lt Col Travis Lewis (Lewis, 2015), Lt Col Ben Dustman (Dustman, 2015), Mr. Eugene Layeski (Layeski, 2015), Mr. Charles Stiles (Stiles, 2015), Mr. Craig Murra (Murra C. , 2015), and TSgt Thomas Kneller (Kneller, 2015) were the sources of the information presented in Table 3.

**Table 3. Capability – Requirement Pairings**

| System | Required Equipment |
|---|---|
| Real-Time Information in the Cockpit (RTIC) | SATCOM Antenna<br>PRC-117 UHF SATCOM Radio<br>Joint Range Extension (JRE) |
| Dynamic Retasking Capability (DRC) | SATCOM Antenna<br>PRC-117 UHF SATCOM Radio<br>JRE |
| Link 16 | SATCOM Antenna<br>PRC-117 UHF SATCOM Radio<br>JRE |
| Tanker Airborne Long-Range Chat (TALC) | mIRC/XMPP chat (DISA provided) access via existing SIPR computers<br>Ground Entry Point (Iridium phone VPN) |
| Roll-On Beyond Line-Of-Sight Enhancement (ROBE) Spiral 3 | SATCOM Antenna<br>PRC-117 UHF SATCOM Radio<br>JRE |
| Internet Protocol Beyond Line-of-Sight (SIPR/NIPR BLOS) | Existing SIPR/NIPR computers |
| Combat Track II (CTII) | TACC-Owned CTII Equipment |
| WAVE Radio Over Internet Protocol | Software for existing SIPR computers<br>Headsets capable of communication over SIPR |
| Mobile User Objective System (MUOS) | Existing STE Terminals |
| User-Defined Operational Picture (UDOP) | Global Awareness Decision Support (GLADS) Servers<br>GLADS Software License<br>Existing SIPR/NIPR Stations |

**Personnel Requirements**

If TACC is to add new systems, it must also consider whether or not it is necessary to bring in new personnel to operate those systems. This generally means ensuring the right people are in place for troubleshooting a system when it is not operating properly or updating hardware and software as necessary. These responsibilities can generally be fulfilled through contract support or by a supporting communications squadron. Systems that provide TDL connectivity, however, require highly trained personnel to properly maintain the tactical data network (TDN). In fact, Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3115.01 (2014) specifically states that the considerable complexity of a data network requires individuals specially trained in planning and manning data network operations. There are various organizations and personnel with varying capabilities in performing the necessary tasks. The most pertinent for TACC is the Joint Interface Control Cell (JICC). Table 4 provides a description of each duty position within the JICC, the required Air Force Specialty Code of the individual filling the position, and the associated responsibilities. In order to maintain 24-hour operations, CJCSM 3115.03 Vol III (2014) recommends a team of 19 personnel in a JICC: 1 Joint Interface Control Officer (JICO), 3 JICC Watch Officers (JICWO), 6 TDL Manager (TDLM), 3 Track Data Coordinators (TDC), 3 System Administrators, and 3 Communication Technicians.

**Table 4. JICC Manning**

| Title/Position* | Required AFSC* | Responsibility* |
|---|---|---|
| JICO | 13B – Air Battle Manager (ABM) | OIC of the JICC. Responsible for planning, managing, and executing the data link network architecture. |
| JICWO | 13B or 1C5 – Aerospace Control and Warning Systems | Shift supervisor. Monitors day to day operations of the TDLs and coordinates troubleshooting efforts of the TDCs and TDLMs. Typically the most experienced link operators and use their expertise to help the JICO make informed decisions. |
| TDC | 13B or 1C5 | Responsible for the completeness, timeliness, and accuracy of the link data. Includes track data management such as changing identifications, resolving conflicts, and deleting stale tracks. |
| TDLM | 1C5 | Sets up and maintains data links for the AOC and ensures data transfer across the TDLs is complete, timely, and accurate. Charged with making sure all players that need to receive or transmit in the link are connected, and if not he troubleshoots and corrects the problem. |
| System Administrator | 3D0X2 – Cyber Systems Operations | Designs, configures, installs, and manages data services at the operating system and server application level. |
| Communications Technician | Not Specified | Provides basic communications focal point (CFP) information technology (IT) support. |

*From AFI13-AOCV3, AMC Supp (2014) and CJCSM 3115.03 VOL III (2014)

## Summary

Based on the current and emerging capabilities presented in this section, TACC is capable of providing AMC with many, if not all, of the desired effects AMC has identified. However, this will require the right mix of systems and personnel, and it will come at a cost. The remainder of this paper focuses on determining the appropriate cost and manning to provide TACC with the desired effects.

# III. Methodology

## Chapter Overview

This study uses a cost-benefit analysis to reach recommendations on action that should be taken by TACC and AMC leadership. In general, a cost-benefit analysis compares each of the costs associated with a certain course of action with each of the benefits tied to that course of action. What follows is a description of the cost-benefit analysis used to reach and support the recommendations of this paper.

## Cost-Benefit Analysis

The first step in the cost-benefit analysis of this study was determining the equipment TACC requires in order to access the various communication systems available. This was accomplished by analyzing the method of communication that each system used, then determining a ground-based system capable of receiving and transmitting via the same means. For example, the KC-46 will be equipped with a Link 16 system capable of communicating via JREAP-A over UHF SATCOM. JRE is the ground-based system that will provide TACC with the equivalent capability.

In many instances, the ground-based system presented in this paper is only one of several options. In these cases, the cost of the ground-based system and the expertise of multiple SMEs were used to determine which system to present for analysis. For instance, JREAP-A communication is possible using multiple gateway systems such as Joint Range Extension (JRE) or Joint Air Defense System Integrator (JADSI). JRE is recommended below based on the input of multiple SMEs and its lower cost as compared to JADSI.

There are also many instances where TACC either already has the requisite system in place or has already begun developing the system. In these cases, it is assumed that TACC will maintain its current capabilities and continue its current pursuits. Therefore, cost information for these systems was not considered.

Once each aircraft-based system was paired with a ground-based system, the cost, in rough order of magnitude (ROM), of each piece of ground-based equipment was determined in one of two ways. If a current user of the equipment could be identified, that user was asked for the purchase and operational expenses of the equipment. If a user could not be found, the ROM cost was requested from experts who have had operational experience with the equipment in the past. Personnel requirements were determined in the same manner.

The benefits of each system are based on that system's capabilities as they relate to the desired effects pulled from the MAF GSC2AGC OC: Networking, Predictive Battlespace Awareness, Dynamic Battlespace Management, and Integrated and Responsive Air Mobility Operations. Of course, the desired effects are necessarily broad, and not every system that adds to an effect meets the effect's full intent. Thus each desired effect is divided into four metrics to allow a more precise analysis. Systems are scored against each metric on a scale of 0 to 2. A score of zero indicates the associated system does not add to the metric. A score of 1 indicates the system adds to the metric, but does not meet the full intent. For instance, a system providing voice communication may enhance C2 decision capability, but not as well as a system that provides a COP. Finally, a score of 2 indicates the system meets the full intent of the metric.

To maximize objectivity, these metrics were presented to a panel of 11 subject matter experts for independent scoring. Of these 11, 6 SMEs from TACC, AMC/A3C, AMC/A3D, and AMC/A6 provided scores. Each SME's score was equally weighted averaged with each other and scores given based on the research of this paper. Appendix A presents the resulting metric scores and Table 6 presents the overall totals for each system as related to each desired effect. This total score provides a quantitative value to what would otherwise be a qualitative assessment of how well a system meets the desired effect.

With both the costs and benefits determined, the cost-benefit analysis was accomplished. The recommendations below were developed by considering whether or not each cost is worth the associated benefit.

**Summary**

Comparing quantitative costs with qualitative benefits to complete a cost-benefit analysis has some challenges. The most significant challenge is the inability to draw an irrefutable conclusion. Although multiple experts were consulted before a conclusion was drawn, the recommendations below are still based on individual perception and opinion. Ultimately the reader must determine whether or not each benefit is worth the cost.

# IV. Analysis and Results

## Chapter Overview

As shown above, AMC is ripe with capability. From DRC to UDOP, AMC's assets and TACC hold the potential to fulfill each one of the desired effects listed above. With the desired effects identified, the capabilities described, and the TACC requirements determined, it is now necessary to determine the costs and benefits of each system.

## Equipment and Software Costs

The majority of systems listed in Table 3 will not cost TACC any more than it has already paid or committed to pay. That is to say, TACC has either already purchased the equipment/software or is in the process of purchasing it. Table 5 contains price information for the equipment and software that TACC needs in order to access those systems to which it does not currently have access. Systems are not presented in Table 5 if TACC already has or is developing the system. Though the list is relatively short, it is also quite important because each of the systems that provide TDL connectivity require an item from Table 5.

**Table 5. Equipment and Software Costs**

<table>
<tr><th>System</th><th>Equipment/Software</th><th>Initial Costs</th><th>Total Costs</th></tr>
<tr><td rowspan="3">DRC, RTIC, Link 16, ROBE (JREAP-A and JREAP-C communications)</td><td>JRE</td><td>$90K - $110K</td><td rowspan="3">Initial Cost:<br>$120K - $160K+<br><br>Annual Cost:<br>$10K – $15K</td></tr>
<tr><td>PRC-117 UHF SATCOM Radio, Cabling, and Antenna</td><td>$30K - $50K</td></tr>
<tr><td>SIPR Software / Network Setup</td><td>Unknown</td></tr>
<tr><td>UDOP</td><td>GLADS Servers and Software</td><td>$4M</td><td>Initial Cost: $4M<br>Annual Cost: $250K</td></tr>
</table>

**Matching Capabilities to Desired Effects**

Table 6 provides a quantitative analysis of the benefits of each system. This table assigns a score to each system based on the extent to which that system fulfills the desired effect. As a means of comparing one system to another, scores for each system are totaled in the right-hand column.

**Table 6. Capabilities v. Desired Effects**

| System | Networking | PBA | DBM | Integrated, Responsive Operations | Total |
|---|---|---|---|---|---|
| DRC | 2.31 | 3.71 | 4.43 | 4.14 | 14.60 |
| RTIC | 2.31 | 3.71 | 4.43 | 4.14 | 14.60 |
| Link 16 | 2.29 | 3.71 | 4.43 | 4.00 | 14.43 |
| TALC | 2.00 | 2.71 | 3.57 | 2.29 | 10.57 |
| ROBE | 1.29 | 2.67 | 2.57 | 2.86 | 9.38 |
| IP BLOS | 4.81 | 4.86 | 5.86 | 4.86 | 20.38 |
| CTII | 3.36 | 2.76 | 3.60 | 2.71 | 12.43 |
| WAVE | 3.27 | 3.33 | 5.17 | 3.33 | 15.10 |
| MUOS | 4.90 | 4.00 | 6.43 | 4.29 | 19.62 |
| UDOP | 5.05 | 6.33 | 5.83 | 6.50 | 23.72 |

Based on scoring from the panel of SMEs, most of the TDL systems – DRC, RTIC, Link 16, and ROBE – are lacking in their ability to fulfill the desired effects. UDOP, however, scored quite high. If TACC wishes to pursue a TDL capability, UDOP is the system of choice according to the SMEs. It should be noted, however, that DRC, RTIC, Link 16, and ROBE all require the same equipment. Should TACC purchase joint range extension, a UHF SATCOM, and the associated cabling and antenna, then TACC will gain access to all four systems at once. Additionally, DRC, RTIC, Link 16, and ROBE scored relatively well in the areas of Dynamic Battlespace Management and Integrated, Responsive Operations. They were also among the highest scorers in the metric of considering and mitigating threats. This means that these systems would enhance safety in a combat situation.

Another significant result indicated by Table 6 is the SMEs' preference for the systems that TACC already has or is developing, in particular IP BLOS and MUOS. This is fortunate for TACC because it means significant steps have already been taken toward fulfilling the desired effects.

**Discussion**

The purpose of this study was to determine what current and emerging communication systems TACC should pursue in order to enhance its global communications capability. The list of potential systems is varied and substantial. The paper presents 10 systems that are either currently available or will become available over the next several years. This list is not exhaustive. There are other systems that were not included for various reasons. For example, the Command and Control Interoperability System (C2IS) equipped on certain KC-135R aircraft might be considered. However, this system is currently dedicated for communication between the KC-135 and special operations forces. It was, therefore, left off the list. Other systems were not included in order to keep this paper unclassified and ensure widest dissemination. Still, the list as it stands is evidence that there are sufficient systems available to provide the desired enhancement in TACC's communications capabilities.

Each of these systems requires specific ground-based equipment and software. TACC already has, or is in the process of developing, the equipment and software necessary for Combat Track II, SIPR/NIPR BLOS, WAVE Radio Over Internet Protocol, and Mobile User Objective System. Dynamic Retasking Capability, Real-Time Information in the Cockpit, Roll-On Beyond Line-of-Sight and Link 16 each communicate using JREAP-A, requiring TACC to purchase joint range extension, a UHF SATCOM, associated cabling and antenna, and software for NIPR and SIPR stations. Initial costs for these purchases will be somewhere between $120,000 and $160,000 with recurring annual costs of approximately $10,000 to $15,000. Finally, User-Defined Operational Picture requires TACC to enter a contract for Global Awareness Decision Support servers and software for selected NIPR and SIPR stations that will initially cost around $4,000,000 with a recurring annual cost of approximately $250,000.

These systems also require personnel support. The systems that are not associated with TDL require communications support that is standard to a communications squadron (CS). TACC currently receives this type of support from the 375 CS. However, if TACC begins to manage its own common operational picture using TDL systems (DRC, RTIC, Link-16, and UDOP) the JICC manpower as described in CJCSM 3115.03 VOL III (2014) and AFI13-AOCV3, AMC Supp (2014) will be required. The advantage gained by establishing a JICC within TACC is threefold. First, it will aid in fulfilling the requirements laid out in CJCSM 3115.03 VOL III (2014) and AFI13-AOCV3, AMC Supp (2014). Second, a JICC will allow TACC to take full advantage of TDL.

This second point is significant because of the substantial advantages that a properly managed common operational picture can bring. A COP provides real-time in-transit visibility of aircraft as well as critical battlespace information such as weather, restricted flight zones, and friendly and enemy activity. Consider the following fictional scenarios:

Scenario 1: A C-17 is scheduled to depart from Ramstein Air Base, Germany to airdrop supplies to civilian personnel who have been isolated by a terrorist group in Iraq. Shortly after the C-17 departs, the civilians are forced to flee to another location due to the terrorists' activities. As the C-17 continues its route, TACC's JICC sees from the COP that the civilian personnel have changed locations and enemy forces now occupy the intended drop zone. The JICC passes this information to the C-17's flight manager who then, using one of TACC's secure global communication capabilities, is able to coordinate an alternate drop site with the C-17, thereby ensuring the safety of the aircraft and the successful delivery of the supplies.

Scenario 2: A March AFB KC-135 is scheduled for a mid-Pacific rendezvous with a KC-10 that is taking several F-16s across the ocean. Due to a refueling system malfunction, the KC-10 is unable to continue air refueling with the F-16s, requiring them to divert. Thanks to the COP, members of TACC can see the divert in real-time. They can immediately coordinate with the KC-135 to cancel the launch while simultaneously coordinating divert options with the KC-10. As a result, AMC saves the cost of what would have been a wasted KC-135 mission and positions its KC-10 in the optimum location for receiving maintenance and continuing its mission.

These fictional scenarios demonstrate the usefulness of a JICC as well as the potential benefits of managing a common operational picture and using effective global communication systems. Still, the question remains as to whether or not the systems are worth the cost. Since cost is a quantitative measurement and benefits are qualitative, the two cannot be directly compared. AMC and TACC leadership must view the cost in light of the benefits to make a decision of whether or not the benefits are worth the cost. This will be discussed further in the Chapter V. Conclusions and Recommendations.

**Summary**

TACC is already moving toward fulfilling the desired effects of the MAF GSC2AGC OC. Voice, text, and data systems that provide global communication either already exist in TACC, or are being developed. The main pieces that are missing are tactical datalink capabilities and the generation of a common operational picture. Thus, the conclusions and recommendations section will focus on the requirement for TDL and COP systems and the establishment of a JICC in order to manage the COP.

# V. Conclusions and Recommendations

## Chapter Overview

Capabilities, costs, benefits, and personnel have now all been discussed. This chapter closes out the research with a discussion of what should be done with this information. Conclusions are presented, as are recommended actions. The significance of the research is discussed and areas for further research are provided.

## Conclusions of Research

TACC is already moving in the right direction. The systems that it currently has and the systems that it is developing go a long way in satisfying the desired effects that AMC presents in the MAF GSC2AGC OC. Standout performers include MUOS, UDOP, and the KC-46's IP BLOS. IP BLOS, which requires no additional purchases by TACC, scored among the top three for each desired effect and second overall. MUOS, which TACC is currently developing, is particularly strong in the areas of Networking and Dynamic Battlespace Management. Meanwhile UDOP shines in Predictive Battlespace Awareness and Integrated and Responsive Air Mobility Operations. It would appear that TACC is already well on its way to achieving the desired effects.

What TACC lacks is a solid platform for TDL. UDOP is a powerful but expensive solution. For an initial cost of around $4M and an annual cost of about $250K, TACC will be able to generate a COP that fulfills a significant portion of the desired effects. Unfortunately UDOP does not provide connectivity with MAF assets. This gap can be filled using TACC's non-TDL systems. Additionally, MAF aircraft that are JREAP-A capable can receive COP information from theater JICCs. Thus TACC and MAF aircraft will receive the benefits of global communication and SA-enhancing TDL information.

As TACC begins to integrate TDL into its operations, it will require a JICC capable of managing its COP. Initially, this may be only a few individuals, but with time it will grow to a full-size JICC that includes 1 JICO, 3 JICWOs, 3-6 TDLMs, and 3 TDCs. Based on whether or not the 375 CS can provide adequate support, the JICC may also need as many as 3 system administrators and 3 communication technicians.

**Significance of Research**

The significance of this research is twofold. First, it verifies that TACC is already headed in the direction that AMC wants it to go. The fact that TACC either has currently or is pursuing communication capabilities that play a significant role in fulfilling one of more of the MAF GSC2AGC OC desired effects is an indicator that TACC is on the right path. The second significant piece of this research is its emphasis on TDL and the JICC. The pace of operations is ever-increasing. To keep pace, TACC needs a TDL-based COP and the personnel required to properly manage it.

**Recommendations for Action**

TACC has already taken action on the lowest hanging fruit. Based on the SMEs analysis, WAVE and MUOS will provide the most benefit in the near future. Therefore TACC needs to continue to pursue and expand on these capabilities. They will be the primary source of voice and text communication for quite some time.

Over the next several years, TACC needs to expand its TDL capability. Negotiations for UDOP must be completed as quickly as possible. The $4,000,000 price tag may be difficult to swallow, but it is be worth the cost. As negotiations for UDOP progress, TACC must also look into adding JICC-type positions to its unit manning document (UDM). Having one or more trained, experienced personnel on staff will help ensure proper implementation of the UDOP program. Once the program is up and running, it will require a fully manned JICC for proper COP management.

Of course, the issue of TDL connectivity between TACC and MAF aircraft should also be addressed within the next two to three years. Gateways such as JRE and JADSI are quickly becoming antiquated. TACC must pursue alternative solutions. As mentioned above, equipping MAF aircraft with AWS will close the loop on UDOP, allowing TACC to communicate with its aircraft via TDL. This would be a good place for TACC to begin looking.

**Recommendations for Future Research**

Additional equipment, software, and personnel will come with new requirements for training, process management, and memoranda of agreement (MOA) and understanding (MOU). TACC personnel must be trained to use the new equipment, and JICC personnel have unique training requirements with which TACC leadership must be familiar. Use of the new equipment will require the development of concepts of employment and operations to ensure operational procedures are properly documented and adhered to. Finally, global communication equipment, by definition, will cross borders of countries and commands. Research into appropriate MOUs and MOAs must be completed.

Integration of AWS onto MAF aircraft also warrants research. What costs are associated with the system? Can the system be easily integrated into any MAF aircraft? What is the extent of its capabilities? All these questions and more must be answered.

Finally, there may be systems more advanced than joint range extension and joint advanced system integration that will allow TACC to take advantage of the MAF's JREAP-A capabilities. Since the MAF has invested so heavily into systems like ROBE, DRC, RTIC, and Link 16, it is worth the effort to continue the search for more advanced ground-based communication equipment that can capitalize on JREAP capabilities.

**Summary**

TACC is responsible for the planning, scheduling, and execution of AMC's global mission. C2 is the lynchpin that holds the whole AMC operations together. As the world changes and the pace of operations increases, TACC's global reach must continually improve. There are several systems available that could prove critical in enhancing TACC's global communication capability. With the right investment in systems and manpower, TACC will be equipped to meet any challenge that lies ahead.

## Appendix A. Metric Calculations

The following tables contain the breakdown of scores used in Table 6 to determine the extent to which each communication capability meets each desired effect.

**Table 7. Networking Metrics**

| Networking | | | | | |
|---|---|---|---|---|---|
| System | Enhance C2/ Improve Decision Process | Rapidly Report Critical Information | Enable IP-based Networking | Support Mission/ Flight Planning | Total Score |
| RTIC | 1.14 | 1.00 | 0.00 | 0.17 | 2.31 |
| DRC | 1.14 | 1.00 | 0.00 | 0.17 | 2.31 |
| Link 16 | 1.14 | 1.00 | 0.00 | 0.14 | 2.29 |
| TALC | 0.71 | 1.00 | 0.29 | 0.00 | 2.00 |
| ROBE | 0.57 | 0.57 | 0.00 | 0.14 | 1.29 |
| IP BLOS | 1.29 | 1.71 | 1.14 | 0.67 | 4.81 |
| CTII | 1.00 | 1.29 | 0.50 | 0.57 | 3.36 |
| WAVE | 0.83 | 1.67 | 0.60 | 0.17 | 3.27 |
| MUOS | 1.29 | 1.86 | 1.33 | 0.43 | 4.90 |
| UDOP | 2.00 | 0.80 | 1.25 | 1.00 | 5.05 |

**Table 8. PBA Metrics**

| Predictive Battlespace Awareness | | | | | |
|---|---|---|---|---|---|
| System | Asses Changing Conditions/ Anticipate future conditions | Establish Priorities | Exploit Emerging Opportunities | Act With Speed and Certainty | Total Score |
| RTIC | 0.86 | 0.86 | 1.00 | 1.00 | 3.71 |
| DRC | 0.86 | 0.86 | 1.00 | 1.00 | 3.71 |
| Link 16 | 0.86 | 0.86 | 1.00 | 1.00 | 3.71 |
| TALC | 0.71 | 0.71 | 0.71 | 0.57 | 2.71 |
| ROBE | 0.67 | 0.67 | 0.67 | 0.67 | 2.67 |
| IP BLOS | 1.14 | 1.14 | 1.29 | 1.29 | 4.86 |
| CT II | 0.71 | 0.71 | 0.67 | 0.67 | 2.76 |
| WAVE | 0.67 | 0.67 | 1.00 | 1.00 | 3.33 |
| MUOS | 0.71 | 0.71 | 1.29 | 1.29 | 4.00 |
| UDOP | 1.83 | 1.50 | 1.50 | 1.50 | 6.33 |

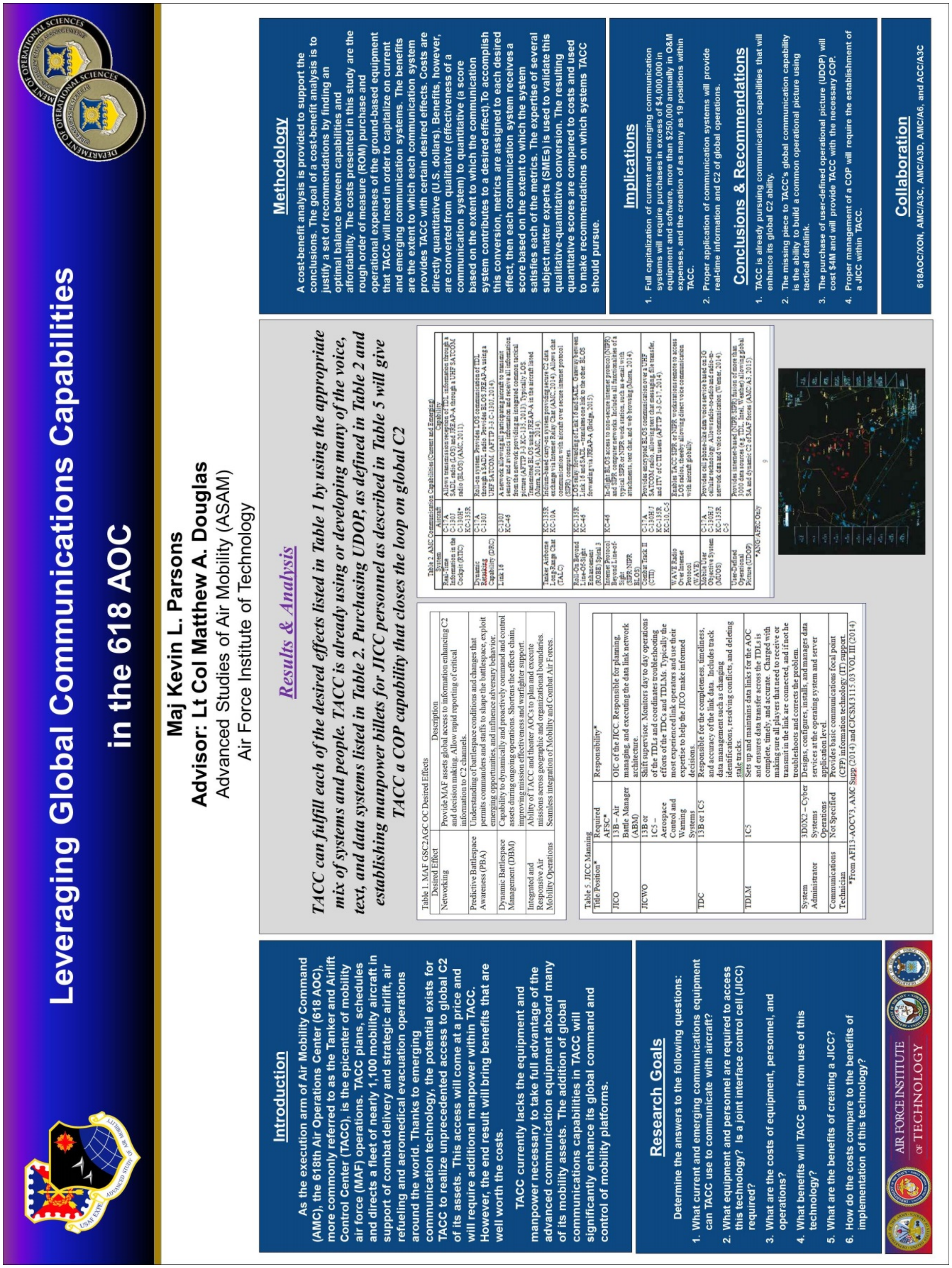
**Table 9. DBM Metrics**

| Dynamic Battlespace Management | | | | | |
|---|---|---|---|---|---|
| System | Direct Changes Before Airborne Missions are Impacted | Shortened Effects Chain | Improved Mission Effectiveness | Improved Warfighter Support | Total Score |
| RTIC | 1.00 | 1.14 | 1.14 | 1.14 | 4.43 |
| DRC | 1.00 | 1.14 | 1.14 | 1.14 | 4.43 |
| Link 16 | 1.00 | 1.14 | 1.14 | 1.14 | 4.43 |
| TALC | 0.86 | 0.86 | 0.86 | 1.00 | 3.57 |
| ROBE | 0.57 | 0.57 | 0.71 | 0.71 | 2.57 |
| IP BLOS | 1.43 | 1.43 | 1.43 | 1.57 | 5.86 |
| CTII | 0.71 | 0.71 | 1.00 | 1.17 | 3.60 |
| WAVE | 1.33 | 1.33 | 1.17 | 1.33 | 5.17 |
| MUOS | 1.57 | 1.71 | 1.57 | 1.57 | 6.43 |
| UDOP | 1.50 | 1.33 | 1.33 | 1.67 | 5.83 |

**Table 10. Integrated and Responsive Air Mobility Operations Metrics**

| Integrated and Responsive Air Mobility Operations | | | | | |
|---|---|---|---|---|---|
| System | Seamlessly Integrate with CAF | Assist with Conduct of Global Ops | Consider & Mitigate Threats | Dynamic Adaptation to Changing Environment | Total Score |
| RTIC | 1.00 | 0.86 | 1.29 | 1.00 | 4.14 |
| DRC | 1.00 | 0.86 | 1.29 | 1.00 | 4.14 |
| Link 16 | 1.00 | 0.86 | 1.14 | 1.00 | 4.00 |
| TALC | 0.57 | 0.71 | 0.29 | 0.71 | 2.29 |
| ROBE | 1.00 | 0.57 | 0.57 | 0.71 | 2.86 |
| IP BLOS | 1.29 | 1.29 | 1.14 | 1.14 | 4.86 |
| CTII | 0.29 | 1.00 | 0.71 | 0.71 | 2.71 |
| WAVE | 0.67 | 1.17 | 0.67 | 0.83 | 3.33 |
| MUOS | 1.00 | 1.57 | 0.71 | 1.00 | 4.29 |
| UDOP | 1.33 | 1.67 | 1.83 | 1.67 | 6.50 |

## Appendix B. Quad Chart



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**14. ABSTRACT**

As the execution arm of Air Mobility Command's global mission, the 618 Air Operations Center (618 AOC) requires a secure global communication capability that it currently lacks. It also requires the ability to use tactical datalinks and manage a common operational picture in support of global command and control. This paper discusses ten current or emerging systems that will provide these capabilities as well as the equipment, software, and personnel that the 618 AOC needs in order to access those systems. Using a cost-benefit analysis, this paper provides recommendations on the equipment and software that 618 AOC should purchase or develop. The paper also suggests the creation of a joint interface control cell (JICC) within 618 AOC to handle tactical datalinks and manage the common operational picture. The main purpose of this paper is to provide 618 AOC with the proper systems and personnel to excel in Networking, Predictive Battlespace Awareness, Dynamic Battlespace Management, and Integrated and Responsive Air Mobility Operations.

**15. SUBJECT TERMS**

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